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Microbiology

Doctor 2018 | Medicine | JU

Sheet

Slides

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❖ What is Microbiology?

- ✓ It is the **science of microbes** (microorganisms).
- ✓ It includes many **areas of specialization** such as:
  1. Bacteriology
  2. Mycology (fungi)
  3. Virology
  4. Others: Medical microbiology, Immunology, Food microbiology, Biotechnology, Microbial genetics, Industry, Agriculture, Veterinary.

❖ Microorganisms can be:

Eukaryotic	*Prokaryotic*	*Subcellular*
Eu-: real	**Pro-:** before	**Example:**
Karyote: nucleus	**Karyote:** nucleus	Prions

❖ The structure and biochemistry of prokaryotes differ significantly from those of eukaryotes. Here is a comparison chart that shows the key differences between the two classes:

Characteristics	Eukaryotic Cell	Prokaryotic Cell
Distinct nucleus and nuclear membrane	Yes	No
DNA form	Several chromosomes	A single circular chromosome floats in the cytoplasm
Ribosome type	80S (60S & 40S subunits)	70S (50S & 30S subunits)
Membrane bound organelles (e.g. Mitochondria)	Yes	No
Compartmentalization	Yes	No
Mitotic (spindle) apparatus	Yes	No
Sterols	Yes	No
Peptidoglycan cell wall	No	Yes
Uni vs Multi cellularity	Uni. or Multi.	Uni.

***Note:** The cell wall is a protective outer layer of the cell whose major function is to give the cell strength (rigidity) and structure, hence targeting the peptidoglycan is one means of killing a prokaryotic cell (e.g. bacterium) [this is the mechanism of action of some antibiotics].

❖ Microbial World:

1) **Bacteria** [Bacteriology]: prokaryotic organisms.
2) **Viruses** [Virology]:
   - ✓ A virus is not a cell and it is smaller than a bacteria.
   - ✓ Viruses are **cell-dependent**, indicating their reliance on host cells for proliferation.
   - ✓ Only seen by electron microscope.
3) **Fungi** [Mycology]: Yeast and Moulds (eukaryotic)
4) **Parasites** [Parasitology]: Protozoa and Helminths (Metazoa, worm-like parasites).
5) Immunology & genetics (molecular and engineering)
6) **Prions**

Side Note:

Protozoa: unicellular

Metazoa: multicellular

Characteristics	Viruses	Bacteria	Fungi	Protozoa and Helminthes
Cells	No	Yes	Yes	Yes
Approximate diameter (μm)	0.02-0.2	0.5-2	3-10	15-25
Nucleic acid	Either DNA or RNA	Both DNA and RNA	Both DNA and RNA	Both DNA and RNA
Type of nucleus	Non	Prokaryotic	Eukaryotic	Eukaryotic
Ribosome	absent	70S	80S	80S
Mitochondria	Absent	Absent	Present	Present
Nature of outer surface	Protein capsid and lipoprotein envelope	Rigid wall containing peptidoglycan	Rigid wall containing chitin	Flexible membrane
Motility	None	Some	None	Most
Method of replication	Not binary fission	Binary fission	Budding or mitosis	Mitosis

Prof. Dr. Ghada Fahmy Helaly

- **Note:** Although the previous table seems large, the information it contains is relatively easy and most of it can be recalled through common sense. It should not be too hard to study, hopefully.

❖ Prions:

- ✓ "Prion" is short for **Proteinaceous infectious particle.**
- ✓ They are basically **misfolded proteins**.
- ✓ They cause a set of brain (or neural) diseases called **Transmissible Spongiform Encephalopathies (TSE)**, characterized by dementia, sensory, motor, psychic signs and symptoms. (it causes mad cow disease for instance).
- ✓ Cannot be grown in culture.

✓ **Sources of transmission:**

1) By **ingestion** (food intake).
2) By **iatrogenic** factors, i.e. complications that happen to patients while getting medical treatment from healthcare professionals, such as:
   A. Blood transfusion.
   B. Dura mater transplants. (EXTRA: "Dura mater" is a membrane the covers the brain and spinal cord)
   C. Surgery (brain, tonsils, appendix and spleen)

❖ Normal Flora

- ✓ As incredible as it might sound, our bodies are made up of many more microbial cells than human cells. These microbes are not harmful to humans; some are even beneficial, like (E. coli) bacteria which normally live in the intestines of healthy people.

❖ **Definition:** *Normal flora* is the term used to describe the various **bacteria & fungi** that are **permanent** residents of **certain body sites** especially the skin, colon, oropharynx and vagina.

> Viruses and parasites are **not** considered members of the normal microbial flora.

❖ **One Wrong Organism in The Wrong Place May Kill**:

- ✓ Microbes of the normal flora do not cause diseases unless the normal protective barriers (skin, mucosa) are compromised; so as long as they are in their appropriate locations, they are harmless. However, if bacterial cells (e.g. E. coli) leave their usual anatomic sites (the intestines) to other locations (the urinary bladder), especially in immunocompromised individuals, they can cause disease (Urinary tract infection **UTI**).

> Normal flora can normally exist in one or more locations in the body.

❖ **Pros and Cons:**

✓ In terms of "**Pros**", the normal flora protects our bodies: the microbes of the normal flora prevent pathogens from infecting our bodies by competing for attachment sites* or for essential nutrients.

✓ In terms of "**Cons**", the normal flora may act as **opportunistic** pathogens, i.e. they exploit any opportunity to cause disease, such as when the host's resistance is low (weakened immune system).

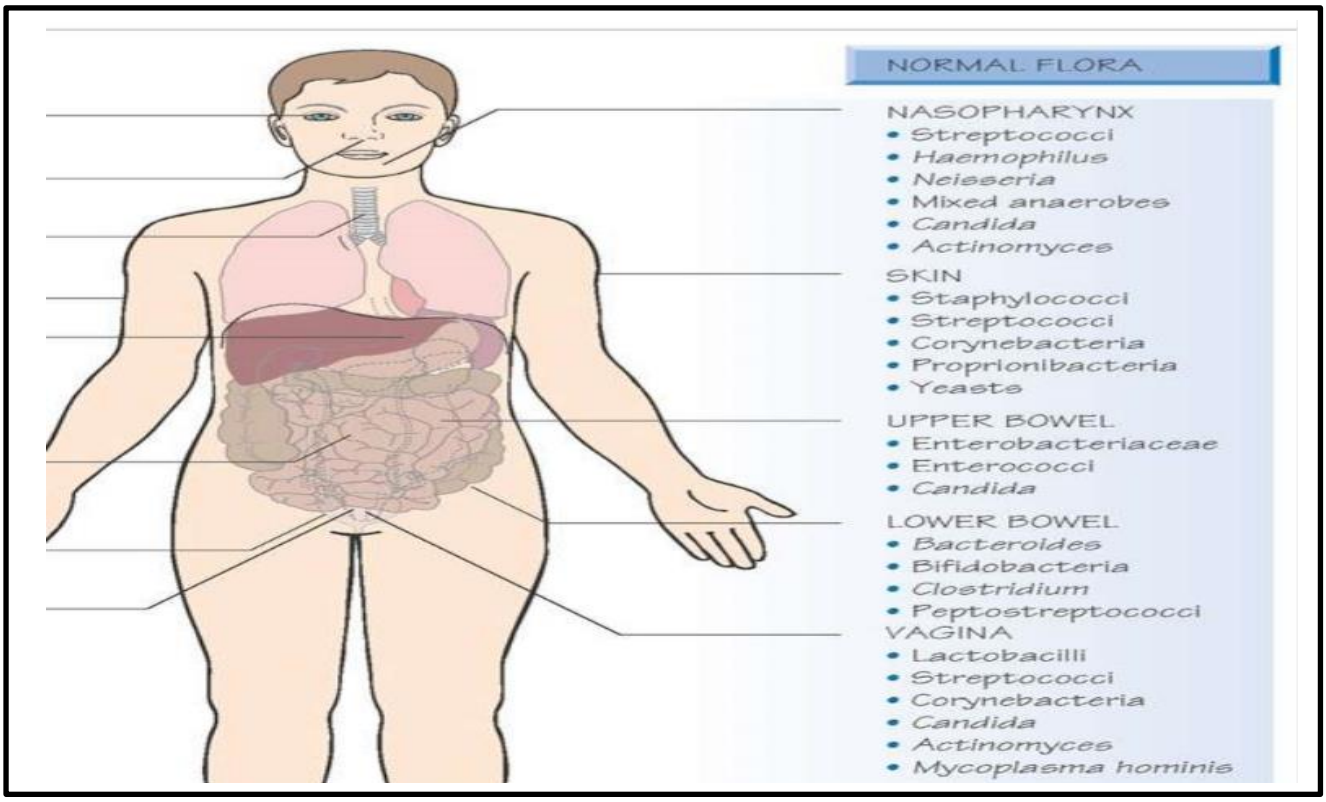
✓ Note: excessive use of antibiotics may negatively impact the normal flora.

*Normal flora impedes the first step of infection: the adherence of pathogens to the cells. They do so by occupying much of the space themselves, leaving no room for exogenous microbes to attach.

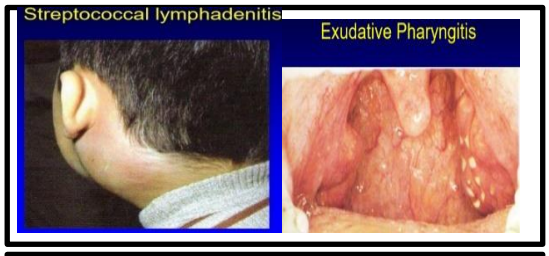
- The human body routinely harbors about **10^{14} bacteria** that exhibit low pathogenic potential, and they constitute the normal microbial flora. **Examples include:**

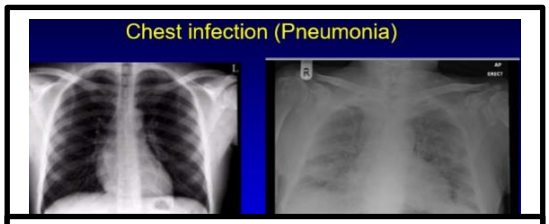
1. CoNS (Coagulase Negative Staphylococci).
2. Micrococci.
3. Diptheroid species.

- The following image provides examples of the normal flora and their respective locations in the body. Note that one type of bacteria may normally exist in more than one area in the body.
- Unfortunate news: we are required to memorize the names and locations.



- ***WASH YOUR HANDS!*** Exudative Pharyngitis, Streptococcal Lymphadenitis, and Pneumonia (Chest Infection) are all examples of diseases you can get by coming into contact with contaminated surfaces.





- ✓ In the UK: 25% of doctors' consultations are infection related.
- ✓ 10% of these infections are hospital acquired.
- ✓ Worldwide, 10 million young children die from infectious diarrhea, measles, malaria, tetanus and whooping cough. Also, 20% of deaths are infection-related.
- ✓ 12000 deaths from HIV yearly.
- ✓ Millions with hepatitis C.
- ✓ Multidrug resistant tuberculosis.

- ***TOO CLEAN IS BAD!*** One of the main problems with the "antibacterial" cleaning products is that they don't just kill the bad bacteria– they eliminate your good bacteria (which reinforce the immune system) too. Therefore, killing these good bacteria by excessively using antibacterial products is the perfect recipe for allergies and infection!

❖ Some (not boring) History (Dates are not required)

- ✓ **Antony van Leeuwenhoek** 17th c: **observed live microorganisms** (animalcules) in water, mud and saliva.
- ✓ **John Hunter** 18th c: Syphilis and Gonorrhea **can be transmitted**.
- ✓ **Edward Jenner** 18th-19th c: Established the **concept of vaccination**, Cow pox and Small pox*.

*Smallpox is a disease (caused by a virus) with 30-40% mortality rate. The last naturally occurring case was in Africa, 1976. It has been eradicated thanks to WHO (World Health Organization) and due to the fact that humans are the only smallpox hosts.

- ✓ **John Snow** 19th c: devised physical measures to **limit** and **inhibit** transmission of **Cholera** in London epidemic (sewage leaking into drinking water).

- ✓ **Ignas Semelweis** 19th c: **Puerperal sepsis** can be **prevented** if the attending nurses apply **hygienic measures**.
- ✓ **Louis Pasteur** 19th c:
  1. **Fermentation of alcohol** by microorganisms.
  2. **Pasteurization**: heating liquid is enough to kill bacteria. (The process involves heating the liquid then rapidly reducing the temperature to eliminate thermophilic bacteria)
  3. **Vaccine development** – rabies, Bacillus anthrax.

- ✓ **Robert Koch** 19th c: – Developed: -
  - **Microbiological media** [which is the growth medium used to grow bacteria. In other words, it contains everything bacteria need to grow outside the body and under laboratory conditions (e.g. nutrients)].
  - **Streak plates** [plates in which the streaking technique (explained briefly below) is applied in order to isolate a pure strain from a species of bacteria] **for pure culture*.**
  - The information in the following box (about steps of cell culturing) is not present in the slides, but was explained by the doctor during the lecture.

*Pure culture does NOT mean (bacteria-free culture). Instead, it refers to a culture having only one type of bacteria.

How do we culture cells? What is the plate-streaking method? (Please make sure you see the link at the end of the sheet regarding this topic to facilitate visualization)

We use a **Petri dish (agar)** which contains the appropriate media/environment (including nutrients) for growth of the microorganism. (note that we are working under aseptic conditions to obtain a pure culture that is not infected with any other microorganism).

We also use a loop (a wand-like tool with a loop at the tip used in transferring bacteria in cell cultures). The loop is sterilized using the Bunsen burner (source of heat), and then cooled down so that the heat of the loop does not kill the organism in the next step.

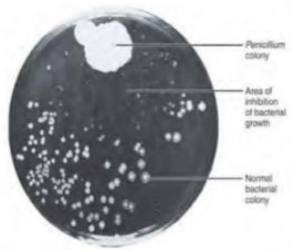
Using the loop, we take some of the infected sample we wish to study (a throat swab for instance, or it could be urine, feces..etc), and then we start **the streaking method** to obtain a pure culture. How? We pass the loop (which now carries many microbes) over the plate in a zigzag-like motion creating streaks, we then repeat the process but at different angles, this process allows for **pure** isolation of the microbe that caused the infection from other irrelevant microbes (through dilution of the number of microbes). The dish is then incubated. The microorganism then appears in the form of colonies. In a pure culture, we would find one type of colony. If different shapes or colors of colonies are found, then the culture is not pure, probably due to unintentional contamination during preparation.

- ✓ **Germ theory (Koch's postulates):**

- ✓ **The microorganism *must* be present in every case of the disease** (The microorganism must be found in abundance in all diseased hosts)
- ✓ **The microorganism *must* be isolated from the diseased host and grown in pure culture.**
- ✓ **Inoculation of the cultured microorganism into (a healthy) host *must* give the same disease**.
- ✓ **The microorganism *must* be recovered (reisolated) from experimentally infected host**.

- ✓ **1917-1921**. **Influenza Pandemic**: Best estimates are 25 – 30 million confirmed dead, millions more suspected.

- ✓ **Alexander Fleming** – 1945 – Discovered **Penicillin** (antibiotic), derived from a species of fungi, Penicillium notatum. (It kills bacteria by targeting the cell wall, as binding of the beta-lactam ring of the antibiotic to the bacterial transpeptidase enzyme inhibits cell wall synthesis in the outer layer of bacteria).



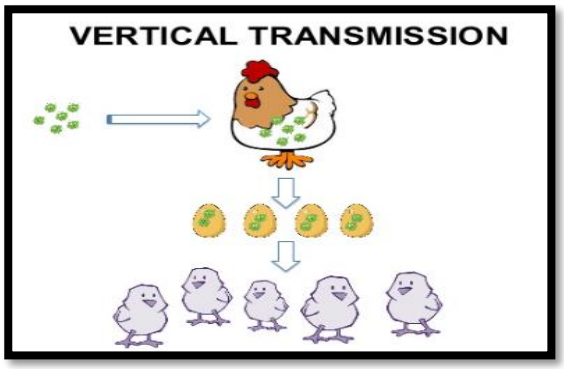
- ✓ **Kary Mullis** 1986: Invented **Polymerase Chain Reaction (PCR).**
- ✓ **Zur Hausen** 1970s-2008: discovered that certain strains of **the human papilloma virus (HPV)** cause **cervical cancer** > leading to the discovery of the cancer-preventing HPV vaccine.

❖ Portal of entry

- ✓ **Definition:** the site through which micro-organisms enter the host and cause infection (disease).

- ✓ **What are the Portals Of Entry?**

1. **Respiratory**: via inhalation.
2. **Alimentary (GIT):** by ingestion.
3. **Genital tract:** via sexual contact
4. **Skin:** Abrasions, bites, …
5. Congenital or vertical (from mother to child)
6. Others: Conjunctiva, blood transfusion, injections and organ transplants.



❖ Common Terms

- ✓ **Incubation period:** the time between acquisition of the organism & the beginning of symptoms, it varies from hours to days to weeks. For example, the incubation period of flu is usually around 1-3 days. For further clarification: When flu symptoms start to appear, you can conclude that you caught the virus around 1-3 days earlier.

- ✓ **Period of communicability**: the time during which the infectious agent may be transmitted (important for infection control).

Statistical Concepts

- ✓ **Incidence:** the number of new cases that develop in a given period of time.
- ✓ **Prevalence:** the number of cases of a disease that are present in a particular population at a given time.

MNEMONIC: **Incidence** looks at new cases (incidents), Prev***al***ence looks at ***all*** current (existing) cases.

- ✓ **Mortality rate:** ratio of number of deaths from a disease in a given year to the total population at mid-year.
- ✓ **Case fatality rate**: the proportion of the patients with the disease who die from it.

Cause-specific mortality rate	$\frac{\text{Deaths from cause}}{\text{Population}}$
Case-fatality rate	$\frac{\text{Deaths from cause}}{\text{Number of persons with the disease/cause}}$

❖ The spread of disease: Endemic, Epidemic and Pandemic

- ✓ The words ***endemic***, ***epidemic*** and ***pandemic*** all indicate the spread of an infectious disease. But what is the difference between these terms?

- ✓ Now, there are some diseases that reside in a particular geographical area. Just like we know that the arctic regions have auroras and Japan experiences tsunamis and earthquakes, similarly, some diseases are almost always present in a particular region. Therefore, an ***endemic*** refers to a disease that exists **permanently** in a **particular region** or **population**. A good example of an endemic is **malaria** which is a constant worry in parts of **Africa**.

- ✓ When an infectious disease spreads to a great number of people, it leads to an outbreak. This outbreak is usually the start of an epidemic. Accordingly, an ***epidemic*** is an outbreak of disease that attacks people at about the same time and may spread through one or several communities. Contrary to an endemic, epidemics are not permanent nor are they restricted to one area at all times.

> Interesting note!
>
> **Epi-** means upon, **pan-** means all, **Demos** means people

- ✓ Quite simply, a pandemic is an epidemic gone mad! By definition, a ***pandemic*** is when an epidemic **spread throughout the world**.

  - Video to better understand cell culture (it contains extra details which you should not worry about, just watch to visualize the process) https://www.youtube.com/watch?v=Ay2hhujTuvg

Good luck... and wash your hands

❖ Quick Quiz:

1. All of the following are distinctive differences between eukaryotes and prokaryotes EXCEPT:

A) The presence of peptidoglycans in cell walls of prokaryotes.
B) Different sedimentation coefficients among eukaryotic and prokaryotic ribosomes.
C) Absence of nucleic acids in prokaryotes.
D) Absence of sterols in prokaryotes.
E) None of the above.

2. Choose the correct statement regarding normal flora:

A) Members of the normal flora include bacterial, fungal and protozoal microbes.
B) Normal flora provides no protection to the body.
C) The normal flora is of no threat in immunocompromised patients.
D) It is resistant to antibiotics.
E) None of the above

3. Which of the following agents lacks the ability to be cultured:

A) Bacteria
B) Fungi
C) Human cells

D) Prions
E) None of the above

4. **A researcher calculated the number of new Malaria cases that arose in a city within the passage of one month, the calculated variable represents:**
A) Incidence
B) Mortality rate
C) Prevalence
D) Case fatality rate
E) None of the above

Answers:
1.C 2.E 3.D 4.A